Landsat Science Team

Landsat Operations Report

7 July 2015

Brian Sauer
Ground System Manager
USGS EROS
bsauer@usgs.gov

U.S. Department of the Interior
U.S. Geological Survey

Agenda

- Mission Status (L7,L8)
- L7/L8 Acquisition Status
- Archive Status
- LGAC Status
- Product Distribution

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Spacecraft Status: L7 Summary

≈ 15 years of on-orbit operations

Power Subsystem

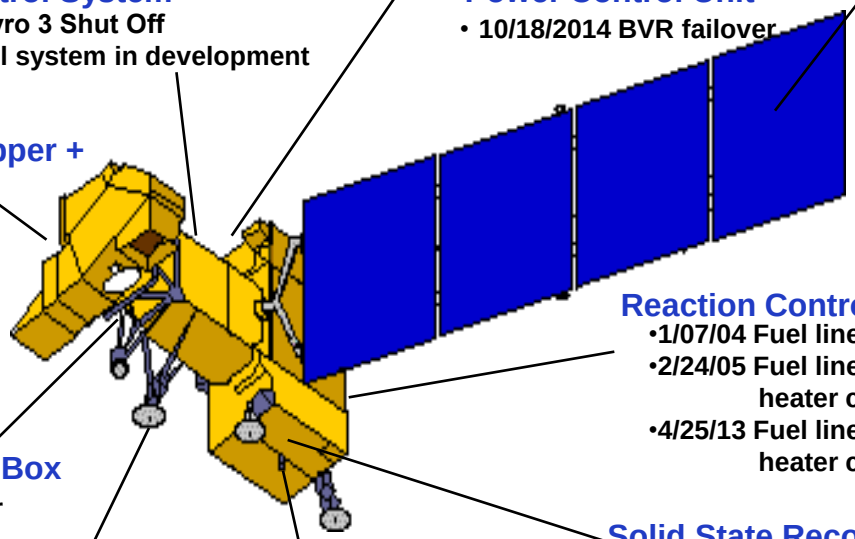
Batteries
Performance nominal

Solar Array
- 5/14/2002 Circuit #14 Failure
- 5/16/2005 Circuit # 6 Failure
- 8/13/2008 Circuit #14 partial recovery
- 14 circuits remain operating
- no impact to ops

Power Control Unit
- 10/18/2014 BVR failover

Attitude Control System
- 05/05/2004 Gyro 3 Shut Off
- 1-gyro control system in development

Enhanced Thematic Mapper +
- 5/31/2003 SLC Failure
- 4/01/2007 Bumper mode



Reaction Control System
- 1/07/04 Fuel line #4 thermostat #1a failure
- 2/24/05 Fuel line #4 thermostat failure; Primary heater circuit disabled
- 4/25/13 Fuel line #2 thermostat failure; Redundant heater circuit disabled

Remote Tlm Cmd (RTC) Box
- 09/27/2014 RTC A Failover

Solid State Recorder
- 11/15/1999 SSR PWA #23 Loss
- 02/11/2001 SSR PWA #12 Loss
- 12/07/2005 SSR PWA #02 Loss
- 08/02/2006 SSR PWA #13 Loss
- 03/28/2008 SSR PWA #22 Loss
- 09/03/2008 SSR PWA #23 Recovered
- 10/12/2013 SSR PWA #11 Loss
- Each PWA is 4% loss of launch capacity
- Boards are likely recoverable

X-band System
Performance nominal

S-band System
Performance nominal

*** No new spacecraft issues to discuss.*

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Mission-Limiting Factors

- **Component Anomalies: Mission status that invokes consideration of decommissioning**
  - **End of Science Mission: A critical failure of either the ETM+ or supporting bus subsystem**
  - **Imminent failure of critical sub-system component capability considered necessary to execute the decommission plan**
    - **Loss of critical subsystem redundancy may not be an exit trigger and would be evaluated on a case-by-case basis**
    - **Examples include ACS gyro or C&DH S-band transponder**
- **Fuel Reserves**
  - **Sufficient fuel must be maintained to meet mission decommissioning requirements**
    - **The satellite is lowered below the operational orbit of the 705km constellation**

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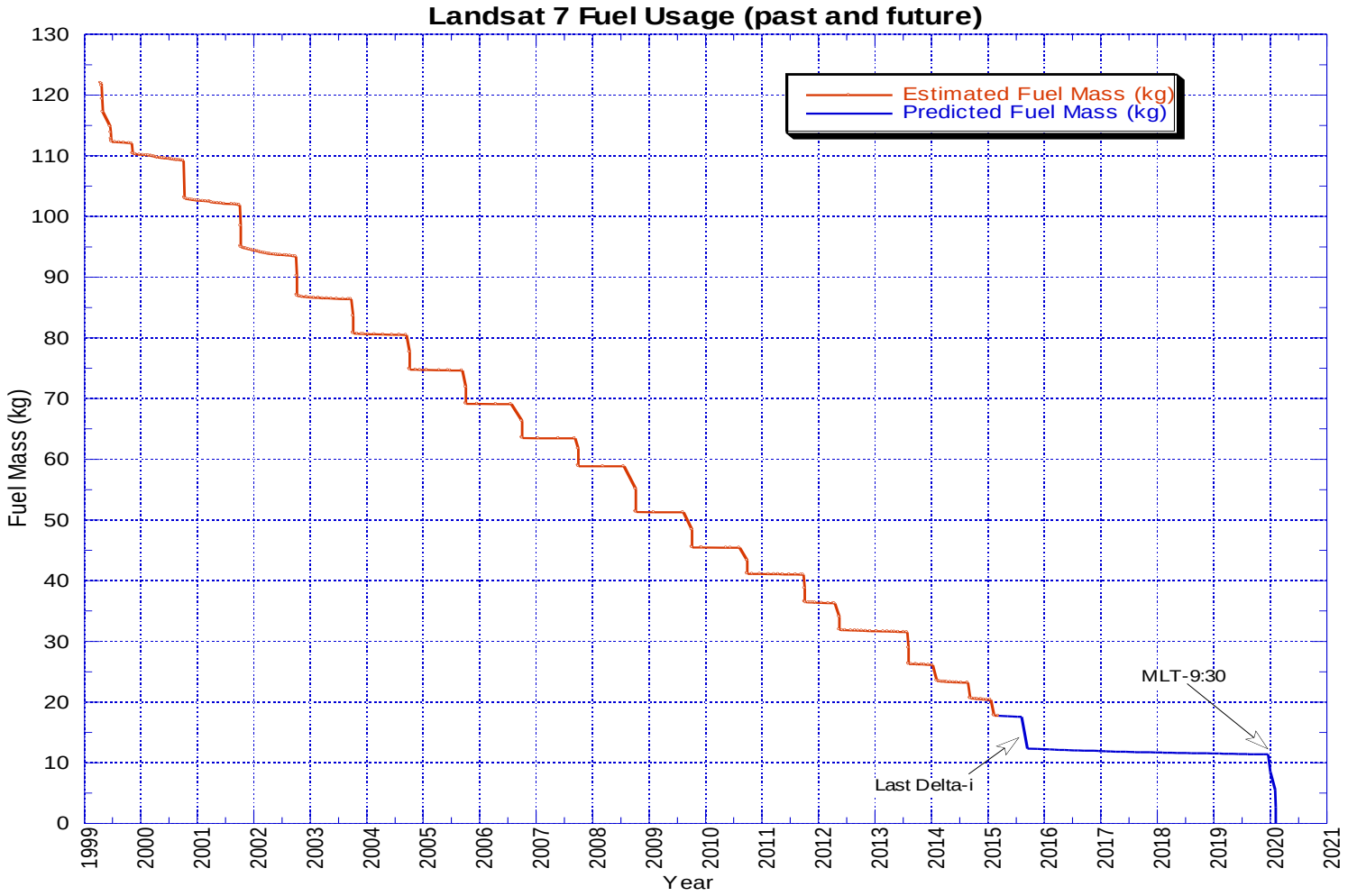
L7 Fuel Estimates



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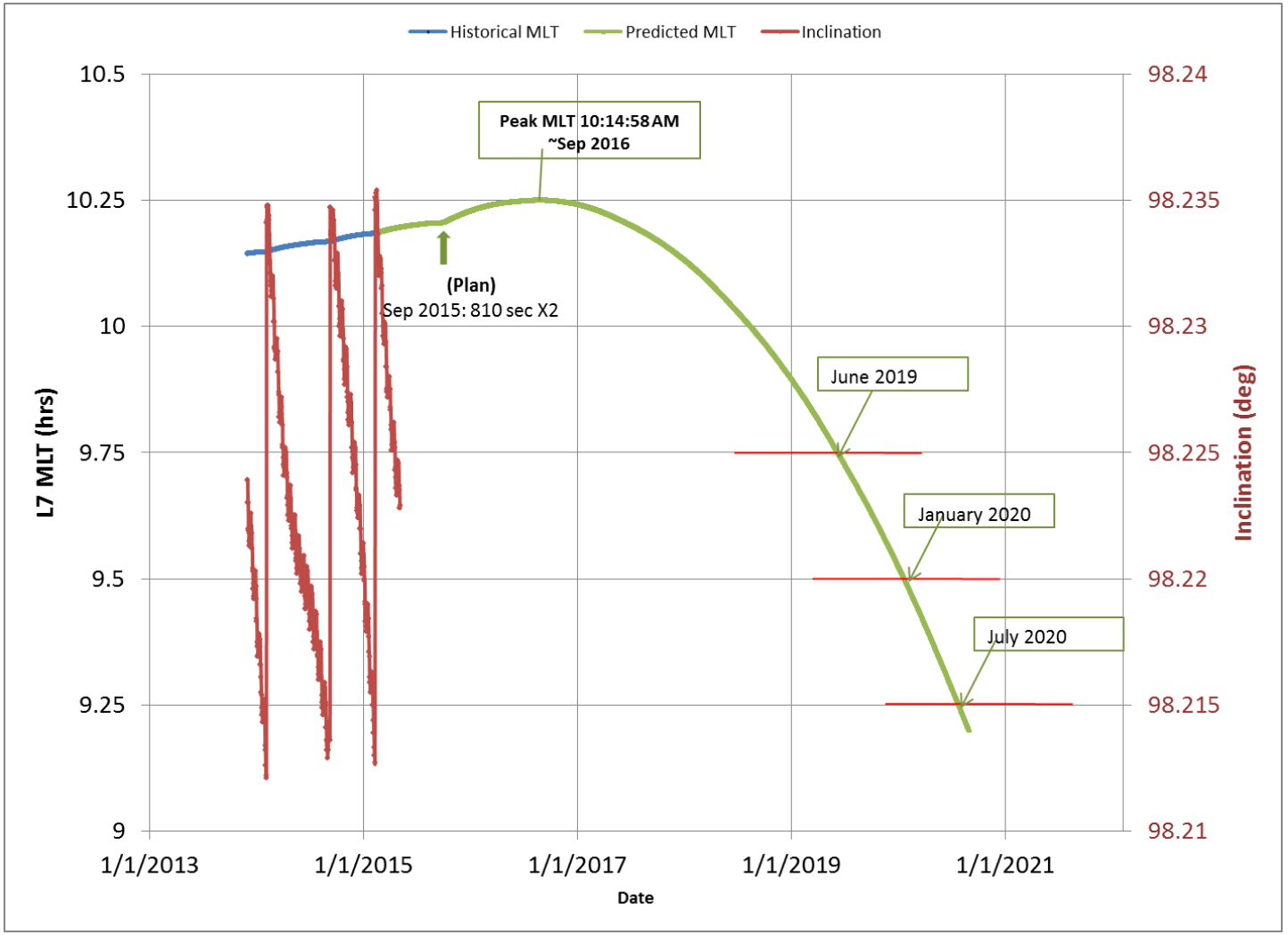
L7 MLT Long-Term Prediction



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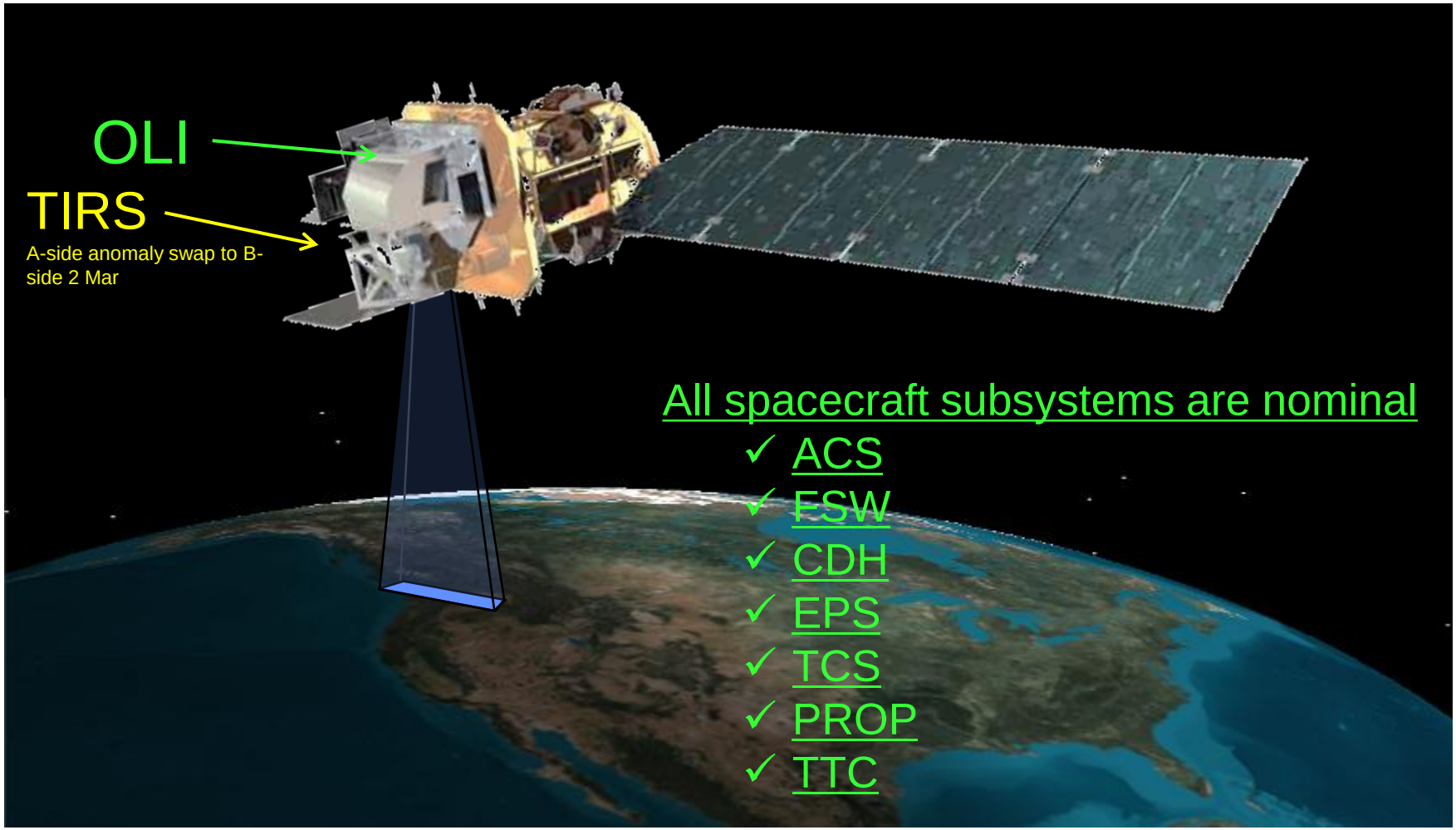
L8 Spacecraft Status



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Ground System Activities Related to TIRS

- **TIRS Anomaly**
  - **19 Dec 2014 – Mechanical Control Electronics (MCE) reached a yellow over-current limit. Scene Select Mirror (SSM) encoder was switched to 'Mode-0' which basically disables the encoder**
    - **TIRS bands in products were set to 0 (until we reprocess to handle mirror drift)**
  - **2 Mar 2015 – TIRS switched to Side-B 'Mode-4'. Commission and calibration period followed**
    - **Develop new parameters for CPF, BPF, RLUT**
  - **30 Apr 2015 – Reprocessing of TIRS data started**
    - **Mode-0 data (19 Dec 2014 – 2 Mar 2015)**
    - **Commissioning data – Side-B 'Mode-4' data (2 Mar 2015 – 30 Apr 2015)**
  - **14 May 2015 – Reprocessing completed**
- **TIRS Stray Light**
  - **Discussion forthcoming (Ron Morfitt)**
  - **Tentatively planned for LPGS 2.6 (~October)**
  - **Plan to reprocess OLI_TIRS data once stray light algorithm is validated**

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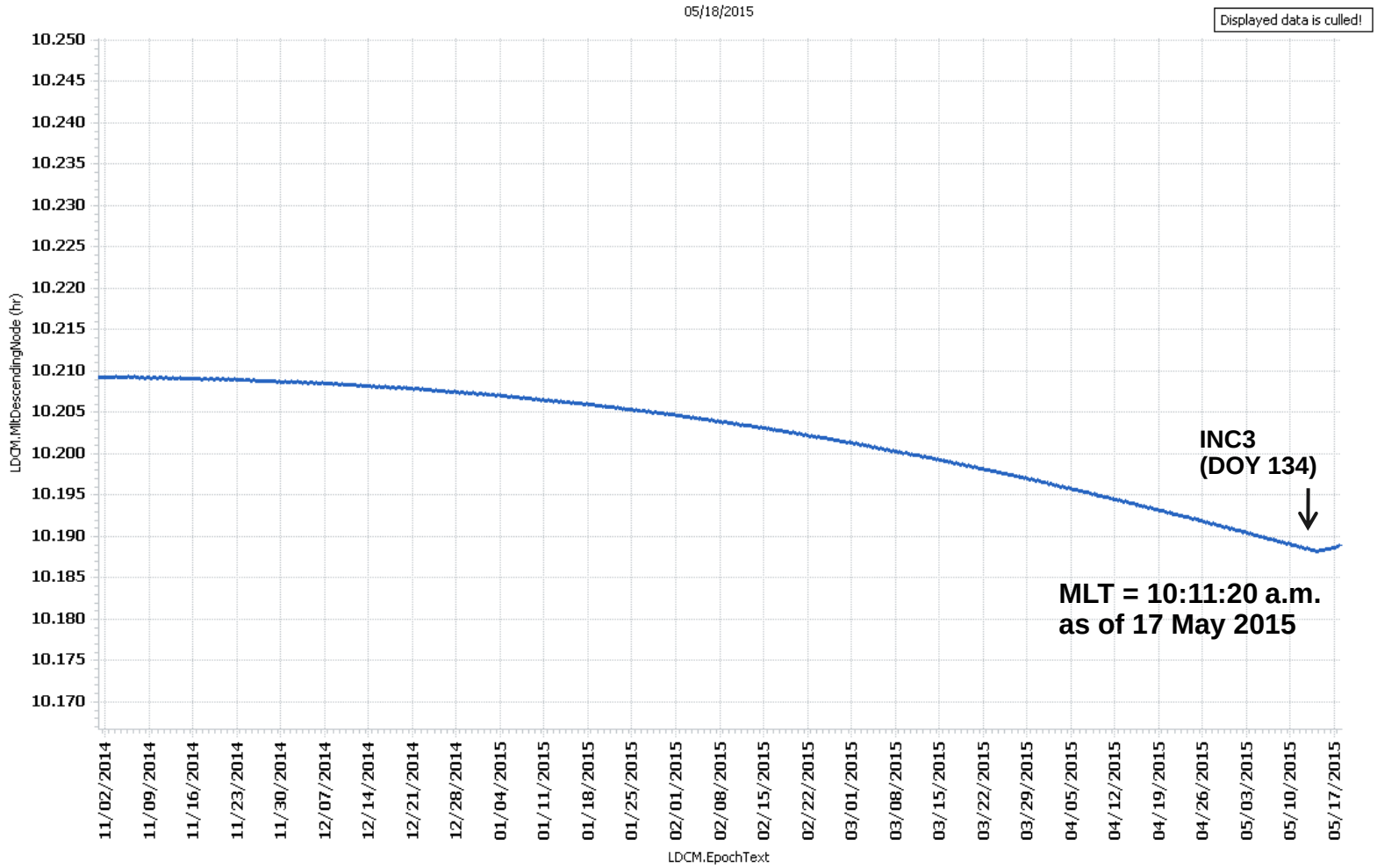
Landsat 8 Mean Local Time (MLT)
1 November 2014 through 17 May 2015



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Landsat 7 and 8 Science Data Acquisition Status

Data not acquired is lost forever!

-- Eugene A Fosnight, PHD
Signature Block

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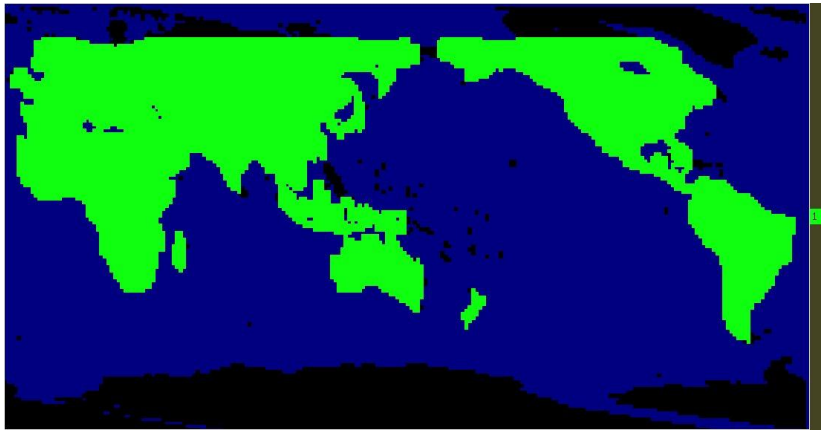
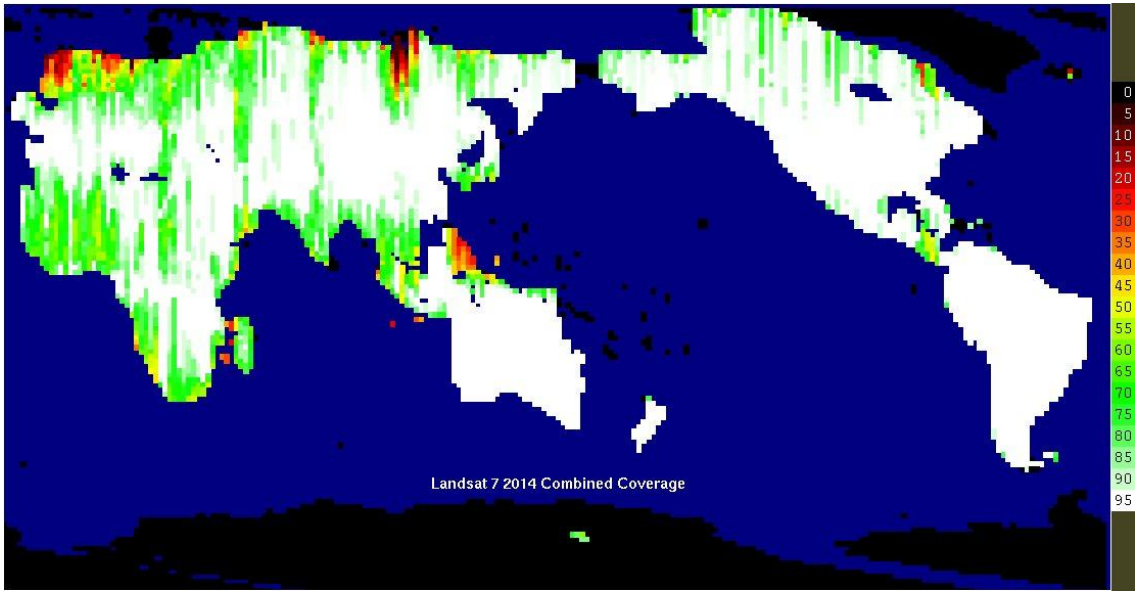
Landsat 7 Current Status

- **Acquire only continental land masses**
  - **Minimize revisit time**
  - **Maximize interval lengths**
  - **Exclude many islands, Antarctica, Greenland, and row 9 and above**
- **Most rejects due to**
  - **Duty cycle**
  - **Onboard memory**
- **No daily limits**
- **Map of % acquired in 2014**





Currently acquiring ~470 scenes/day!

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Landsat 7 Current Investigations

- **Tune Landsat 7 Continental Model**
  - **Acquire as many images as possible**
  - **Acquire the best possible images**
  - **Do nothing to shorten the mission**
- **Reduce duty cycle rejections by relaxing constraints**
  - **Propose gradual increase in duty cycle to 105% of current**
  - **Careful monitoring of telemetry**
  - **Acceptable risk given near end-of-mission?**
  - **Duty cycle rejections tend to shift to memory rejections**
- **Increase download opportunities**
  - **Add International cooperators as “bent-pipe” LGN stations**
  - **Adds operational margin in anticipation of future memory board losses and loss of download opportunities**

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Landsat 8 Acquisition Status (1/1/2015 – 5/19/2015)

- **Daily limit at ~725 images/day**
  - **Acquiring 421 mid-latitude day-lit land scenes (99.4% of candidates)**
    - **Beyond 57° Latitude (rows 20 and 105) there is more than 50% sidelap yielding an 8-day revisit period**
    - **Only reject due to maneuvers**
  - **Acquiring 249 high-latitude day-lit land scenes (89.7%)**
  - **Acquiring 11 descending day-lit water scenes/day (98.6%)**
  - **Acquiring ~25 special request scenes day**
    - **Cloud threshold set on night and ocean requests**

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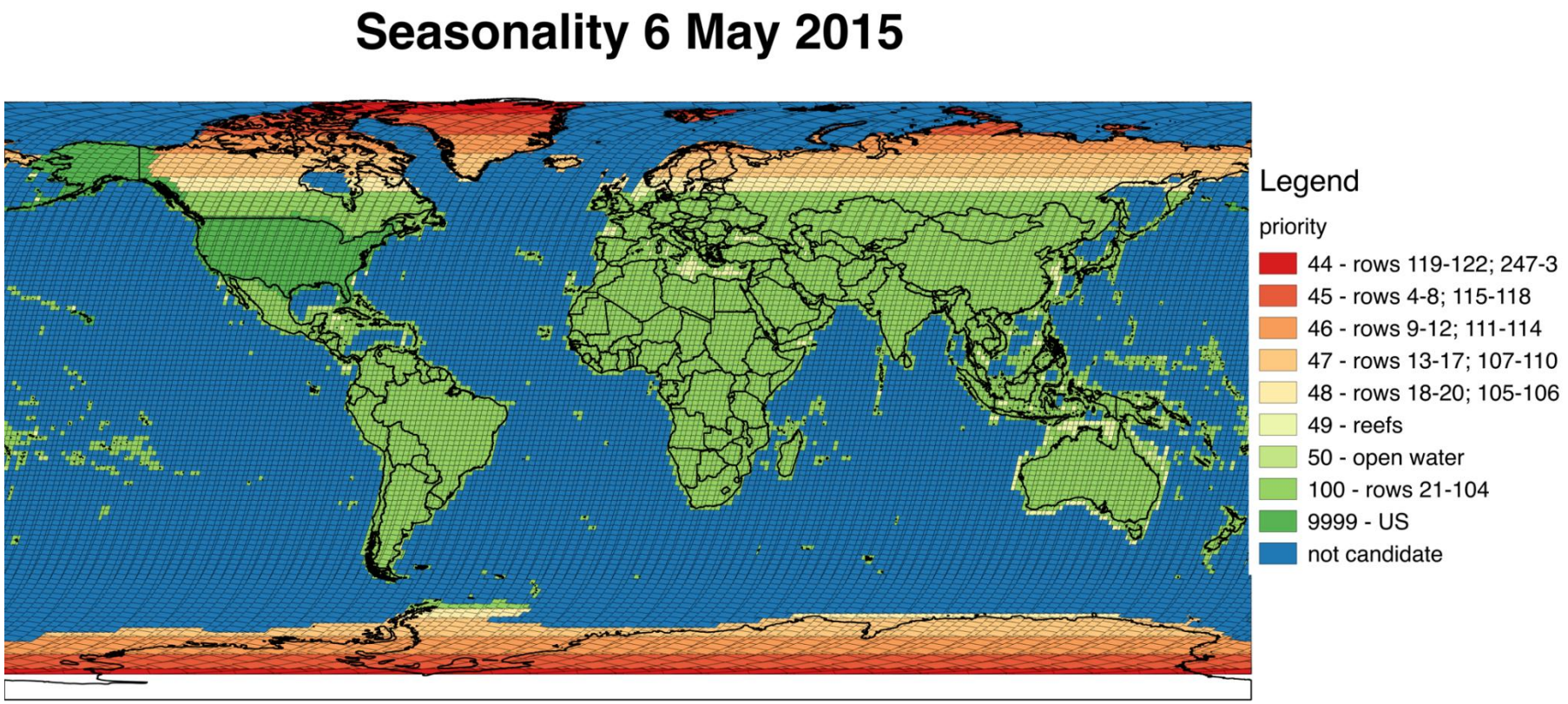
Landsat 8 – Acquisition Priorities



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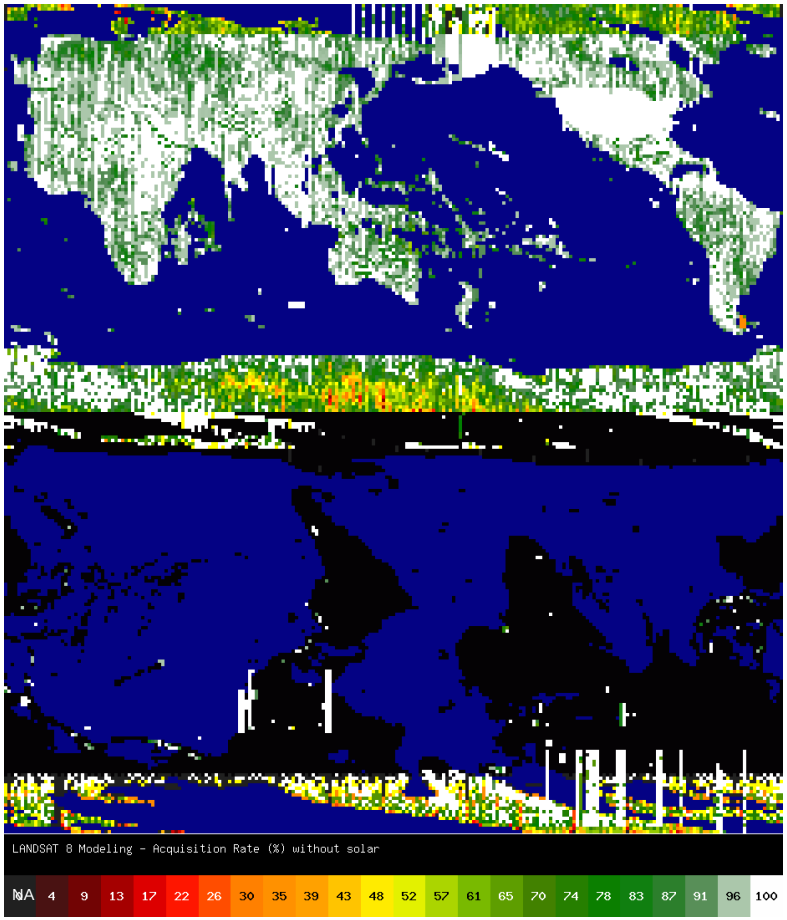
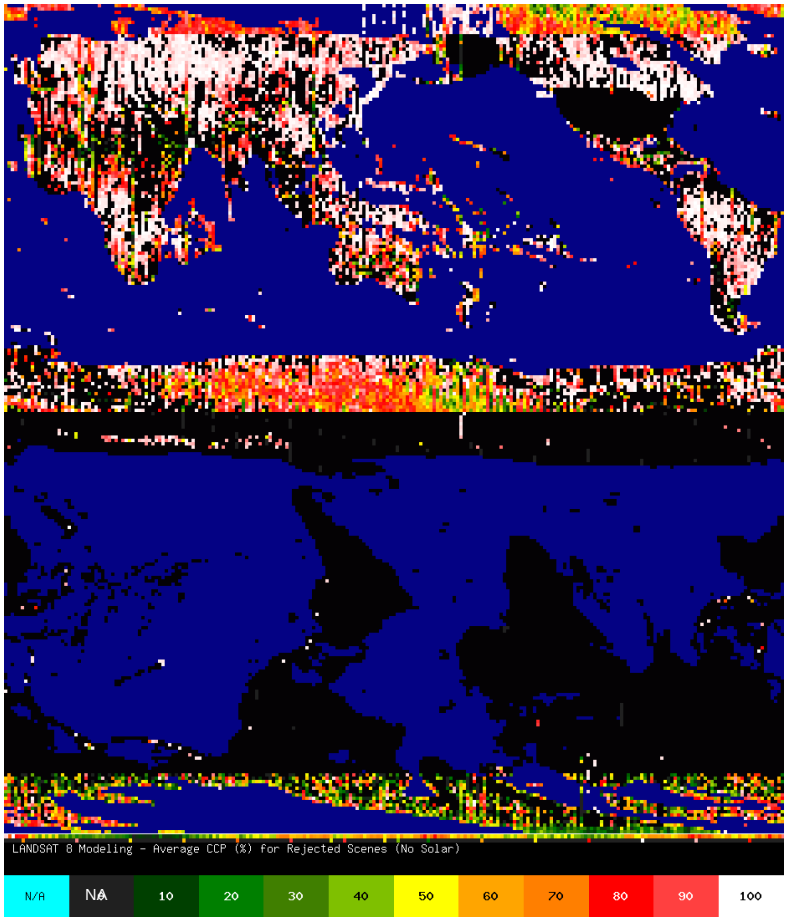
Landsat 8 Acquisitions

2014-06-01 – 2015-05-31



- **Percent acquisitions**



- **Average Cloud Cover Prediction for rejected scenes**

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An Evolving Scheduling Paradigm

- **Landsat 7**
  - **Maximize repeat coverage of continental land masses**
  - **Maximize health and safety of mission**
  - **Coordinate acquisitions with Landsat 8**
  - **Increase ground station contacts and relax duty cycle constraints to maximize acquisitions between now and end-of-mission**
- **Landsat 8**
  - **Continue with 725 limit**
    - **All encompassing - includes special requests**
    - **Consider further reducing day-lit scene restriction**

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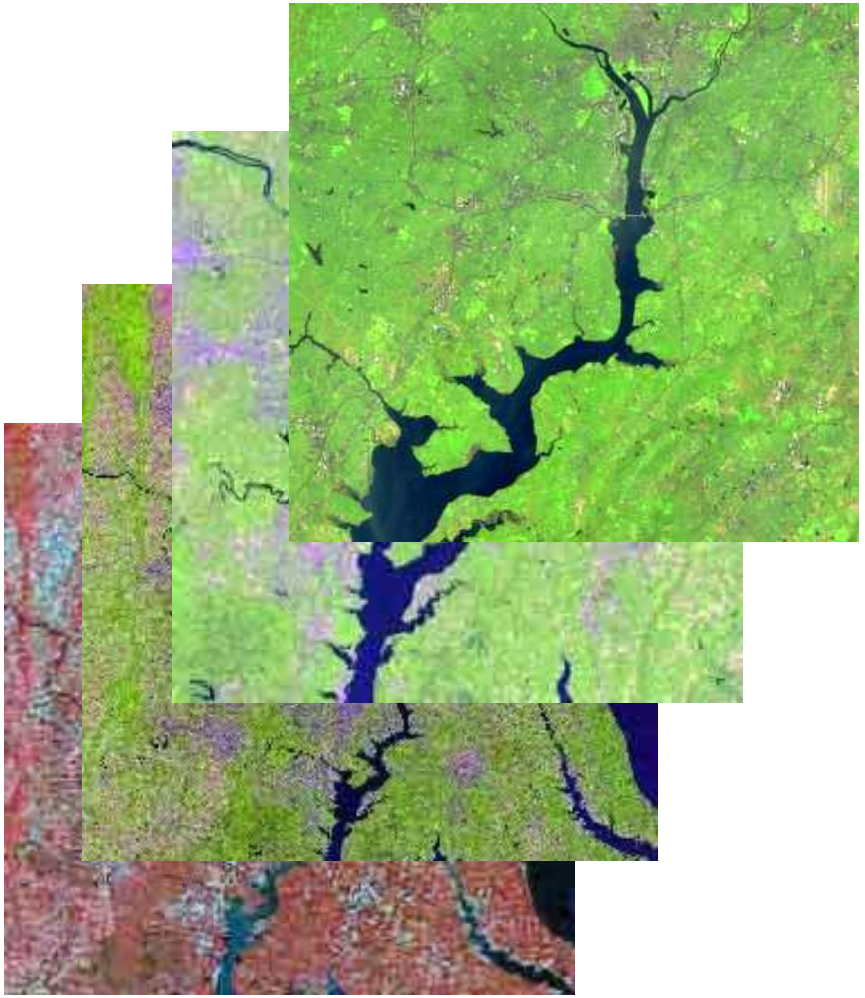
U.S. Landsat Archive Overview
(1 May 2015)

- **OLI-TIRS: Landsat 8**
  - **469,493 scenes**
    - **~ 1,623 TB Raw and L0Ra Data**
      average scene size 1,813 MB
- **ETM+: Landsat 7**
  - **1,936,956 scenes**
    - **~ 1,799 TB Raw and L0Ra Data**
      average scene size 487 MB
- **TM: Landsat 4 & Landsat 5**
  - **2,078,853 scenes**
    - **~ 1,042 TB Raw and L0Ra Data**
      average scene size 263 MB
- **MSS: Landsat 1 through 5**
  - **1,300,091 scenes**
    - **~ 79 TB Raw and L0Ra Data**
      average scene size 32 MB
- **Total:**
  - **5,785,393 scenes**
    - **~ 4,543 TB Raw and L0Ra Data**



All average scenes sizes are for uncompressed data

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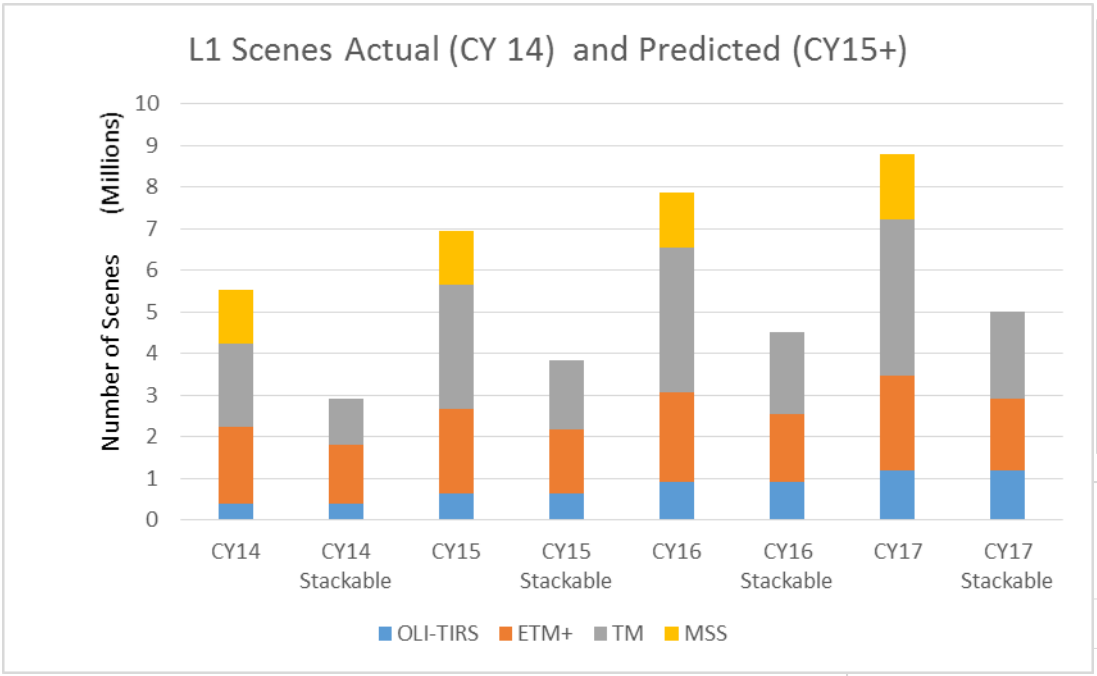
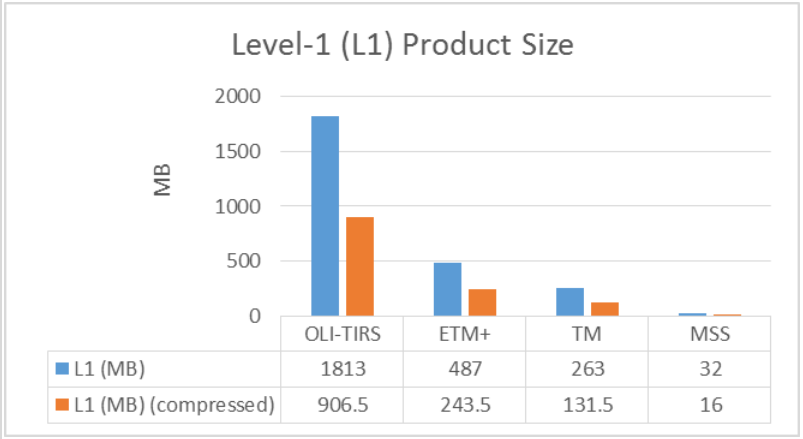
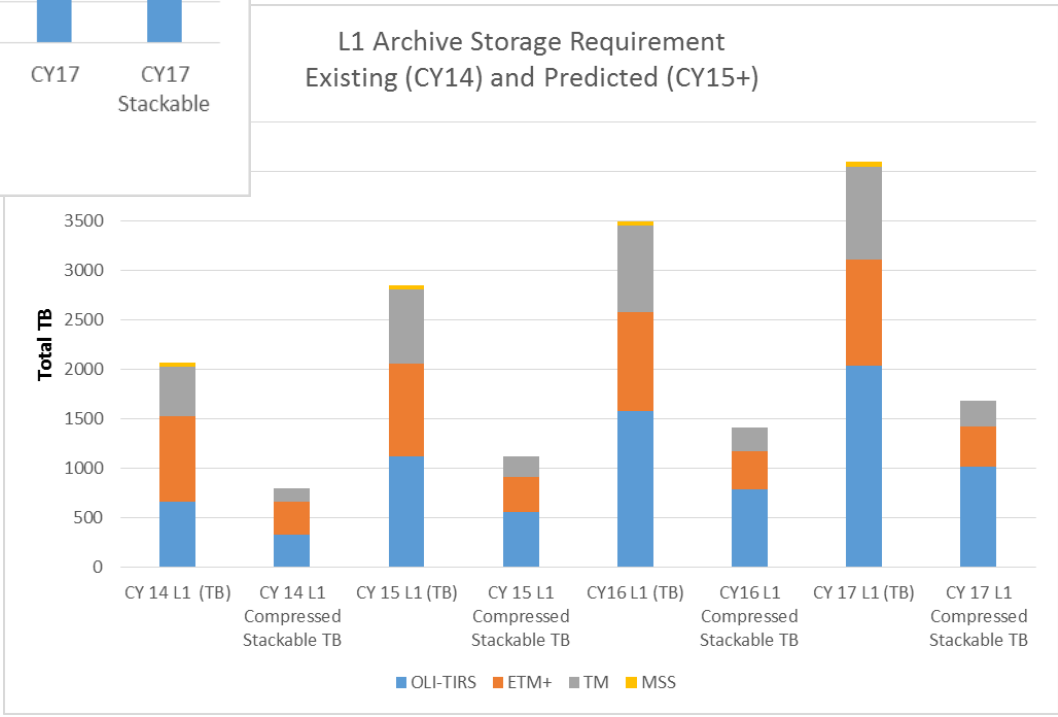
How much data are we talking about (L1T)?





Sensor	% Stackable
OLI-TIRS	100.00%
ETM+	76.00%
TM	56.00%
MSS	0.00%



For High-level Estimation Only

** Rough Estimates **

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LGAC

HDDT drives coming from Thailand

Pakistan data (1,257 HDDTs completed out of 2,540)

HDDTs being sent from Thailand

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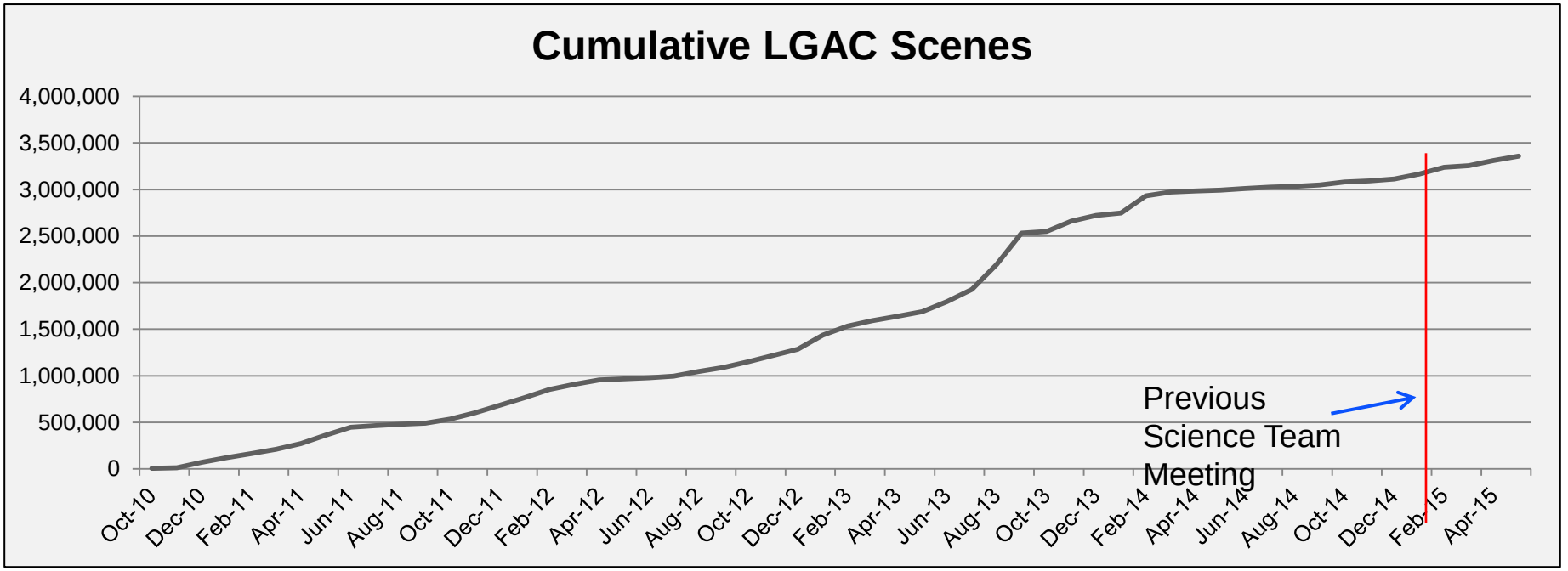
Landsat Global Archive Consolidation (LGAC)



Previous "Woodcock Metric" (1/2/2015): 3,164,701

Current (5/1/2015): 3,356,614 scenes!

~ 6M total (~ 53% complete)

~ 69% of scenes are unique to the archive

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LGAC Status

Country (Organization)	Ground Station	% LGAC Delivered	% LGAC Ingested
Argentina (CONAE)	COA	TM	TM
		ETM+	ETM+
Australia (GA-NEO)	ASA	MSS	MSS
		TM	TM
		ETM+	ETM+
Australia (GA-NEO)	HOA	TM	TM
		ETM+	ETM+
Brazil (INPE)	CUB	MSS	MSS
		TM	TM
		ETM+	ETM+
Canada (CCMEO)	GNC	MSS	MSS
		TM	TM
		ETM+	ETM+
Canada (CCMEO)	PAC	MSS	MSS
		TM	TM
		ETM+	ETM+

- Argentina – LTOs
  - **TM and ETM+ data delivery continues**
- Brazil – HDDTs
  - **USGS to set up Wideband Video Drive to read tapes**
    - **~875 tapes to be sent by Brazil upon sample tape success**
    - **Primarily consist of MSS data, with very small number of TM intervals also included**

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LGAC Status

Country (Organization)	Ground Station	% LGAC Delivered	% LGAC Ingested
China (RADI)	BJC	TM	TM
		ETM+	ETM+
China (RADI)	KHC	TM	TM
Ecuador (IEE)	CPE	TM	TM
Europe (ESA)	FUI	MSS	MSS
		TM	TM
		ETM+	ETM+
Europe (ESA)	KIS	MSS	MSS
		TM	TM
		ETM+	ETM+
Europe (ESA)	MTI	TM	TM
		ETM+	ETM+
Europe (ESA)	MPS	MSS	MSS
		TM	TM
		ETM+	ETM+
Europe (ESA)	NSG	ETM+	ETM+
India (ISRO)	SGI	MSS	MSS
		TM	TM

- China – Electronic data delivery
  - **TM data delivered in FRED format**
- Ecuador – All data has been received
  - **Addressing several problematic tapes**
  - **Partial data redelivery on hard drives being investigated**
- Europe – NAS HDs
  - Phase I LGAC support consisted of Kiruna (KIS) TM data
    - Issues with missing PCD for ~500,000 TM scenes
    - **USGS** analysis currently in progress
  - Phase II LGAC data to consist of all outstanding TM and ETM+ data
    - **First shipment consisted of KIS and MPS ETM+ data**
    - Additional shipments of TM and ETM+ data in 2015
- India – Letter of Cooperation (LOC) has been signed between ISRO and USGS
  - **LGAC data to be delivered to USGS within the upcoming weeks**

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LGAC Status

Country (Organization)	Ground Station	% LGAC Delivered	% LGAC Ingested
Indonesia (LAPAN)	DKI	TM	TM
		ETM+	ETM+
Japan (HIT/HEEIC)	HIJ	ETM+	ETM+
Japan (JAXA/RESTEC)	HAJ	MSS	MSS
		TM	TM
		ETM+	ETM+
Kyrgyzstan (DLR)	BIK	TM	TM
Mongolia (DLR)	ULM	TM	TM
Pakistan (SUPARCO)	ISP	TM	TM
Saudi Arabia (KACST)	RSA	MSS	MSS
		TM	TM
South Africa (SANSA)	JSA	MSS	MSS
		TM	TM
		ETM+	ETM+
Taiwan (CSRSR-NCU)	CLT	TM	TM
Thailand (GISTDA)	BKT	MSS	MSS
		TM	TM
		ETM+	ETM+
US (U of Puerto Rico)	UPR	ETM+	ETM+

- Indonesia – All data has been received
  - **DCRSi drive parts needed for remaining tapes**
- Pakistan – All HDDTs have been delivered
  - **Tape reading in process**
  - **Delivery of additional TM data on LTOs pending**
- Saudi Arabia – Initial sample set of HDDTs successfully received, read, and ingested
  - **Delivery of additional TM and MSS data on DLTs and HDDTs pending**
- South Africa – Electronic data delivery continues
- Thailand – TM and ETM+ data received on LTOs and DLTs and data ingest currently in process
  - **Delivery of additional TM and MSS data on HDDTs, as well as three tape drives, in process**

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LGAC Status Summary

GSID	Country	Location	Scenes Ingested Since Sept. 2010														
			MSS					TM					ETM+				
			Actual	Estimated	% Comp	Unique	% Unique	Actual	Estimated	% Comp	Unique	% Unique	Actual	Estimated	% Comp	Unique	% Unique
ASA	Australia	Alice Springs	223,791	224,000	100%	166,582	74%	184,963	185,000	100%	181,058	98%	207,262	205,000	100%	112,177	54%
BIK	Kyrgyzstan	Bishkek						2,340	2,000	100%	1,749	75%					
BJC	China	Beijing						190,447	560,000	34%	181,652	95%	66	47,000	0%	17	26%
BKT	Thailand	Bangkok	0	57,000	0%	0	0%	123,982	185,000	67%	115,409	93%	18,704	26,000	72%	8,268	44%
CLT	Taiwan	Chung Li						11,586	12,000	97%	11,297	98%					
COA	Argentina	Cordoba						103,598	190,000	55%	96,185	93%	95,852	190,000	50%	34,643	36%
CPE	Ecuador	Cotapaxi						25,246	50,000	50%	12,304	49%					
CUB	Brazil	Cuiaba	0	76,000	0%	0	0%	306,656	307,000	100%	263,745	86%	83,052	80,000	100%	48,753	59%
DKI	Indonesia	Parepare						17,001	32,000	53%	16,670	98%	47,321	45,000	100%	20,767	44%
FUI	Italy	Fucino	0	2,000	0%	0	0%	48	567,000	0%	48	100%	0	51,000	0%	0	0%
GNC	Canada	Gatineau						53,004	53,000	100%	14,681	28%	37,955	38,000	100%	9,988	26%
HAJ	Japan	Hatoyama	158,352	158,000	100%	95,208	60%	131,556	132,000	100%	127,107	97%	20,556	21,000	98%	10,667	52%
HIJ	Japan	Hiroshima											39,365	39,000	100%	15,316	39%
HOA	Australia	Hobart						5,812	6,000	97%	5,767	99%	13,110	13,000	100%	5,255	40%
ISP	Pakistan	Islamabad	0	5,000	0%	0	0%	31,852	60,000	53%	31,247	98%					
JSA	South Africa	Hartebeesthoek	0	18,000	0%	0	0%	73,759	119,000	62%	61,914	84%	25,531	25,000	100%	8,329	33%
KHC	China	KaShi						14,597	23,000	63%	13,542	93%					
KIS	Sweden	Kiruna	0	432,000	0%	0	0%	183,508	300,000	61%	180,755	98%	28,592	43,000	66%	17,764	62%
MPS	Spain	Maspalomas	0	154,000	0%	0	0%	0	50,000	0%	0	0%	7,480	32,000	24%	4,099	55%
MTI	Italy	Matera						2,928	234,000	1%	2,907	99%	20	48,000	0%	3	15%
NSG	Germany	Neustrelitz	5,132	5,000	100%	5,102	99%						2,112	89,000	2%	147	7%
PAC	Canada	Prince Albert	413,758	414,000	100%	201,692	49%	369,687	370,000	100%	193,020	52%	100,374	100,000	100%	28,671	29%
RSA	Saudi Arabia	Riyahd	0	5,000	0%	0	0%	1,608	250,000	1%	860	53%					
SGI	India	Shadnagar	0	12,000	0%	0	0%	0	39,000	0%	0	0%					
ULM	Mongolia	Ulan Bator						556	500	111%	554	100%					
UPR	Puerto Rico	Mayaguez											315	500	63%	118	37%
Totals			**801,033**	**1,562,000**	**51%**	**468,584**	**58%**	**1,834,734**	**3,726,500**	**49%**	**1,512,471**	**82%**	**727,667**	**1,092,500**	**67%**	**324,864**	**45%**

Over 3.3 million scenes ingested!
Approximately 53% complete
Approximately 69% of scenes are new to the archive!

- **Includes partial scenes**
- **Green = Completed**

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LGAC Notional Timeline

International Cooperator			TM					Notes / Notional Timeline (highlights are changes from Winter 2015 LST meeting)
GSID	Countr	Locatio	Actual	Estimat	% Com	Unique	% Uniqu	
BJC	China	Beijing	190,447	560,000	34%	181,652	95%	Anticipate completion of TM by end of ~~2015~~ 2016
BKT	Thailand	Bangkok	123,982	185,000	67%	115,409	93%	Anticipate completion of TM and data (not on HDDTs) by ~~mid-~~end of 2015; Completion of TM data on HDDTs could take multiple years
COA	Argentina	Cordoba	103,598	190,000	55%	96,185	93%	Anticipate completion of TM and ETM+ by mid-2016
CPE	Ecuador	Cotapaxi	25,246	50,000	50%	12,304	49%	Being worked; no anticipated date at this time.
DKI	Indonesia	Parepare	17,001	32,000	53%	16,670	98%	Completion of TM data on DCRSi tapes could take some time due to mold problems on the tapes
FUI	Italy	Fucino	48	567,000	0%	48	100%	Anticipate completion of 1982-1986 and 2000-2001 TM data by ~~early~~ late 2015; TM data from 1987-1999 have poor PCD -- decision on how to handle this data is pending;
ISP	Pakistan	Islamabad	31,852	60,000	53%	31,247	98%	1/2 complete; Completion of TM data on HDDTs could ~~take multiple years~~ complete by end of 2016
JSA	South Africa	Hartebeest hoek	73,759	119,000	62%	61,914	84%	Anticipate completion of TM data by end of 2015;
KHC	China	KaShi	14,597	23,000	63%	13,542	93%	Anticipate completion of TM data by ~~mid-~~end of 2015
KIS	Sweden	Kiruna	183,508	300,000	61%	180,755	98%	Outstanding TM data contains poor PCD (~40% of TM data holdings) -- decision on how to handle this data is pending ~(1991 – 1996; some good data)
MPS	Spain	Maspalomas	0	50,000	0%	0	0%	Anticipate delivery by end of 2015
MTI	Italy	Matera	2,928	234,000	1%	2,907	99%	Anticipate completion of TM and ETM+ data by ~~early~~ end of 2015
RSA	Saudi Arabia	Riyahd	1,608	250,000	1%	860	53%	Completion of TM data on HDDTs could take multiple years
SGI	India	Shadnagar	0	39,000	0%	0	0%	Ingest of TM data by end of 2015
Totals			**1,834,734**	**3,726,500**	**49%**	**1,512,471**	**82%**	

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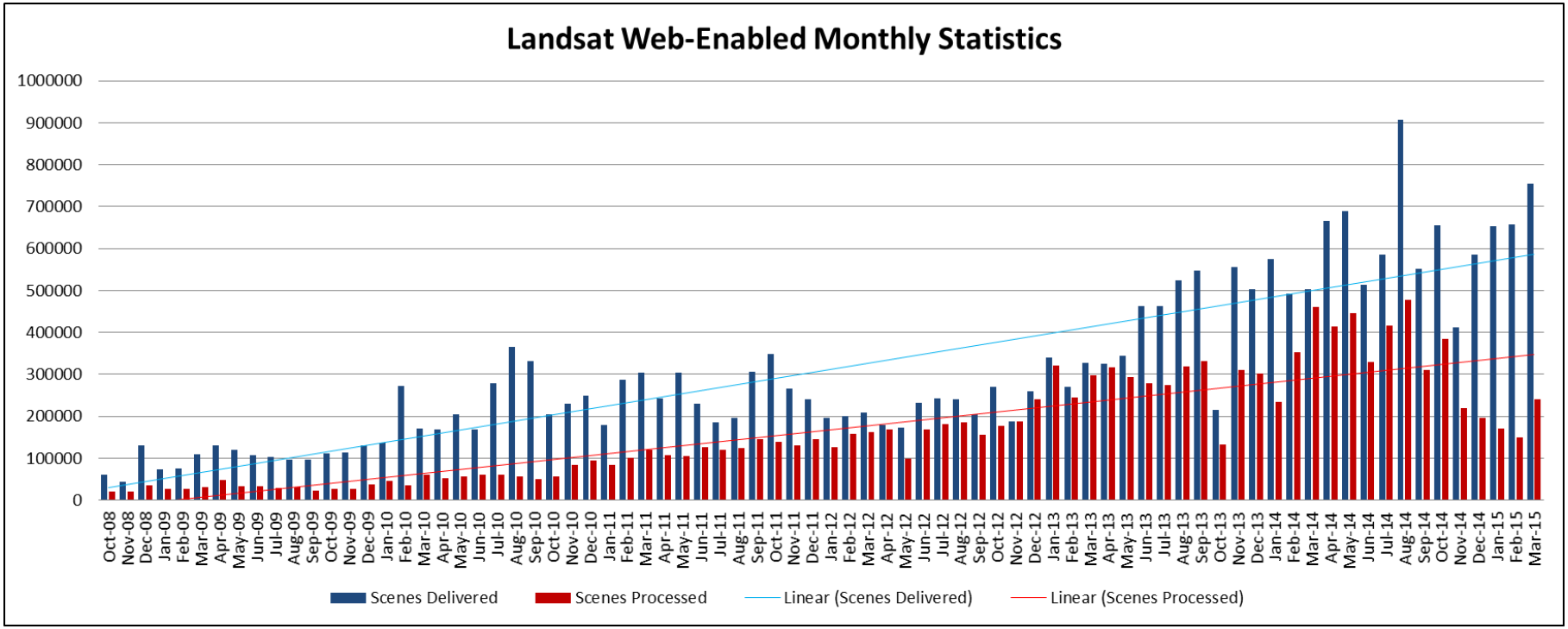
Monthly Downloads/Processed



FY10	FY11	FY12	FY13	FY14	FY15 (*thru March*)
Delivered: 2.45M	Delivered: 2.92M	Delivered: 2.73M	Delivered: 4.32M	Delivered: 6.76M	Delivered: 3.72M
Processed: 567K	Processed: 1.27M	Processed: 1.82M	Processed: 3.28M	Processed: 4.19M	Processed: 1.36M

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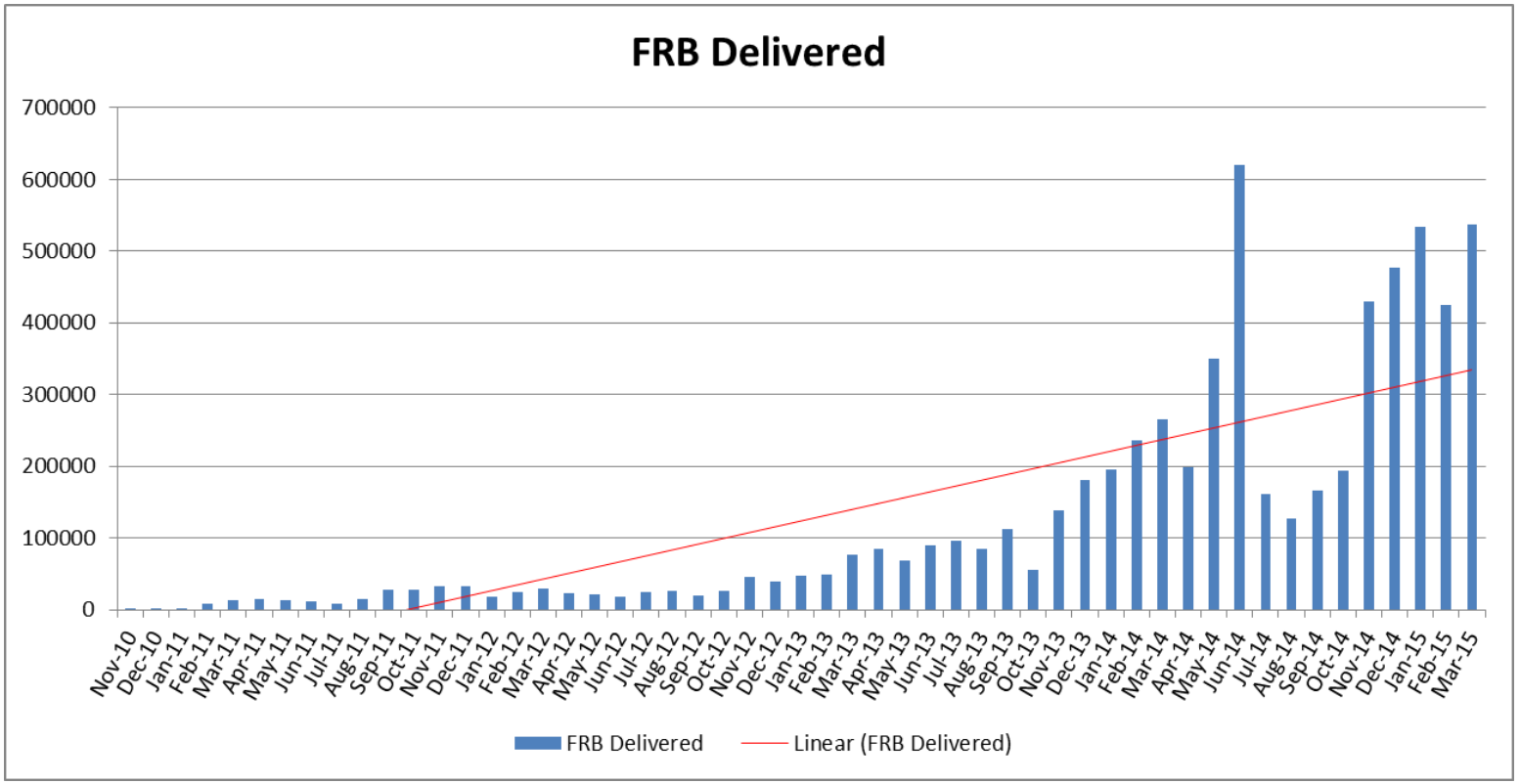
Monthly Full Resolution Browse Downloads



FY11	FY12	FY13	FY14	FY15 (*thru March*)
Delivered: 112K	Delivered: 301K	Delivered: 823K	Delivered: 2,696K	Delivered: 2,596K

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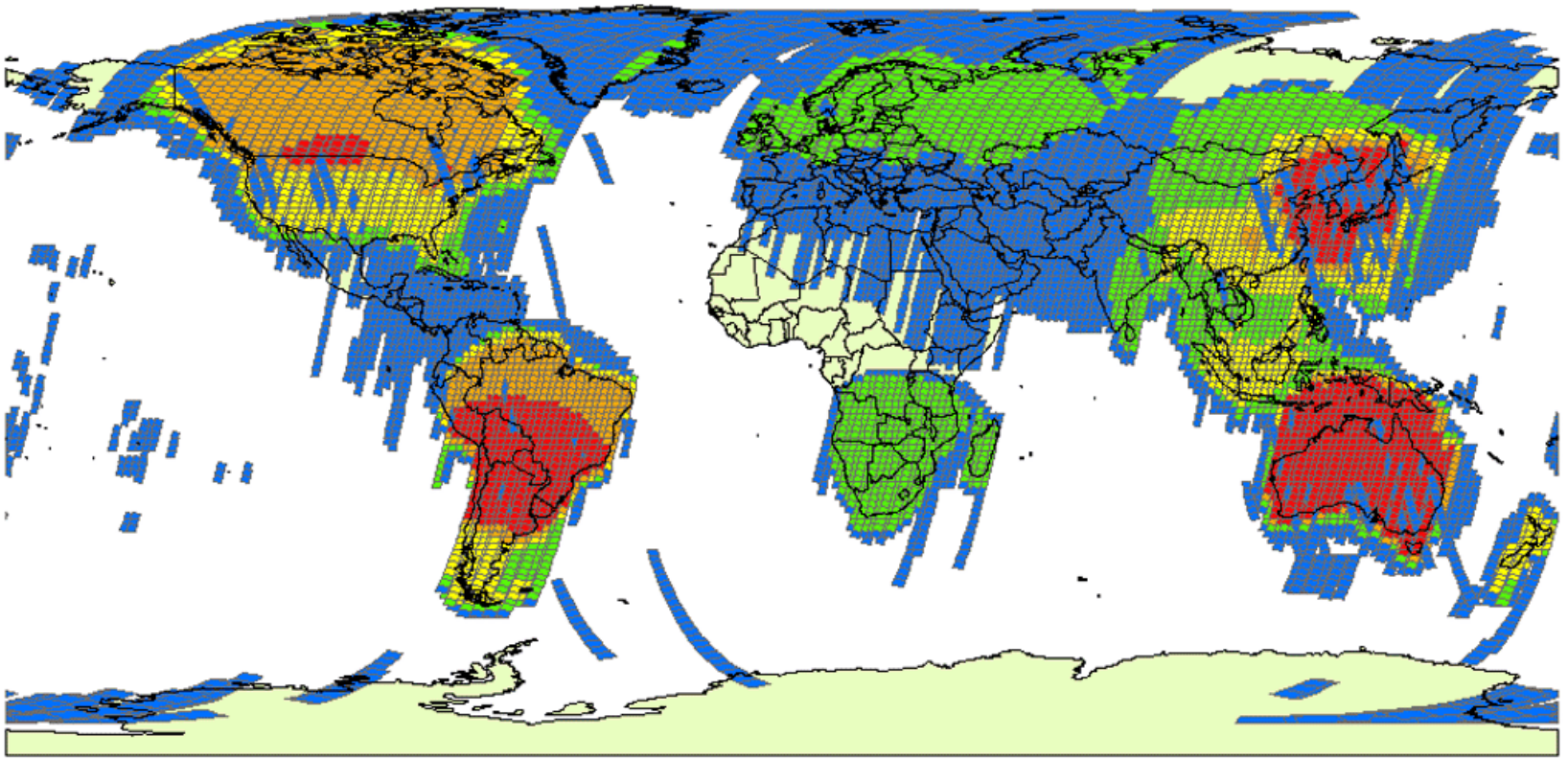
Backup Slides

LGAC WRS-2

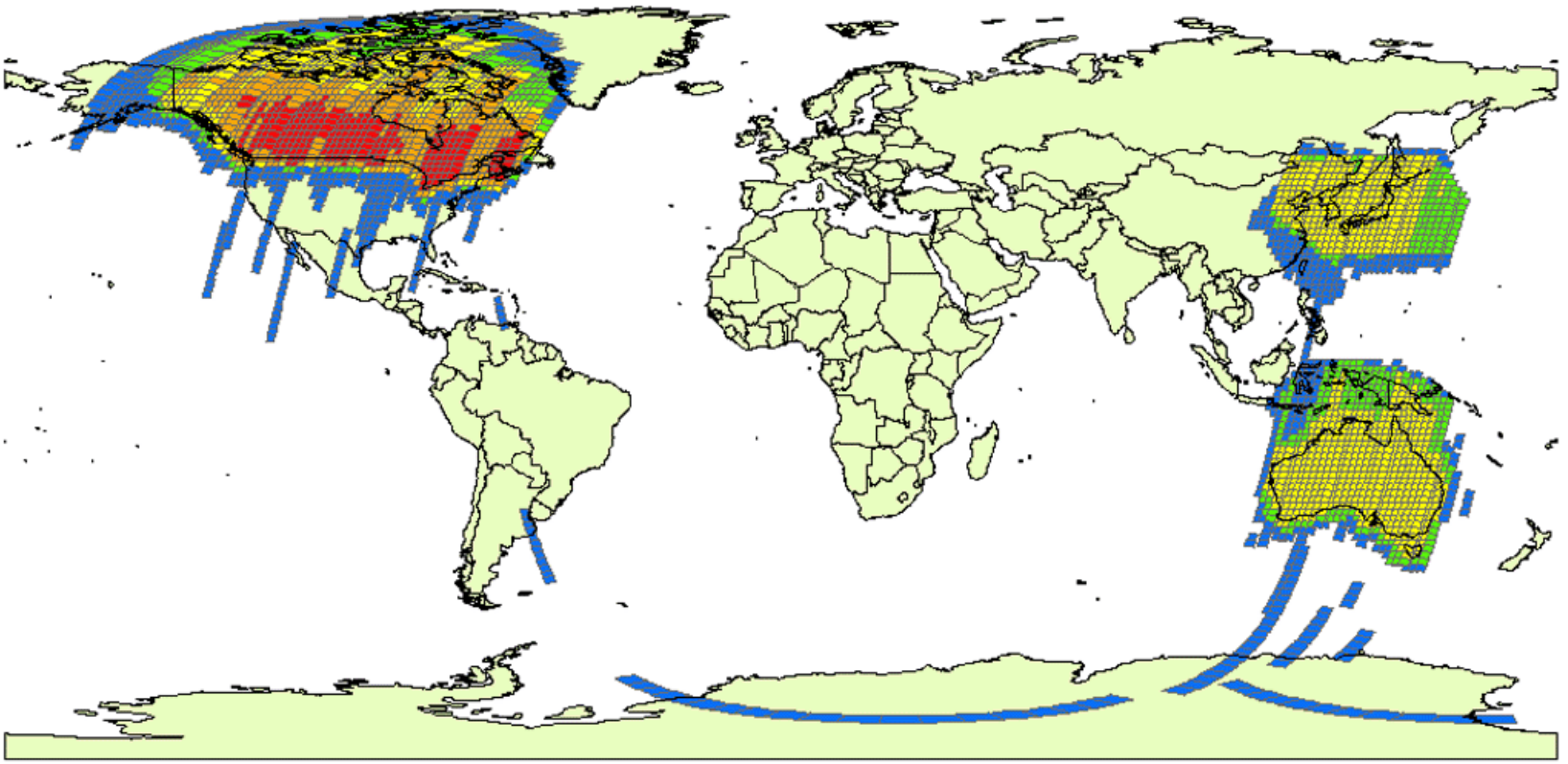


LGAC WRS2 Scenes
Status as of February 28, 2015
Acquisition Date Range: August 22, 1982 through February 28, 2015
3,262,749 Cumulative Scenes Delivered
3,097,736 Total WRS2 Scenes Acquired
13,162 Unique WRS2 Path/Rows

1 - 98 | 99 - 259 | 260 - 485 | 486 - 785 | 786 - 1122

USGS

LGAC WRS-1

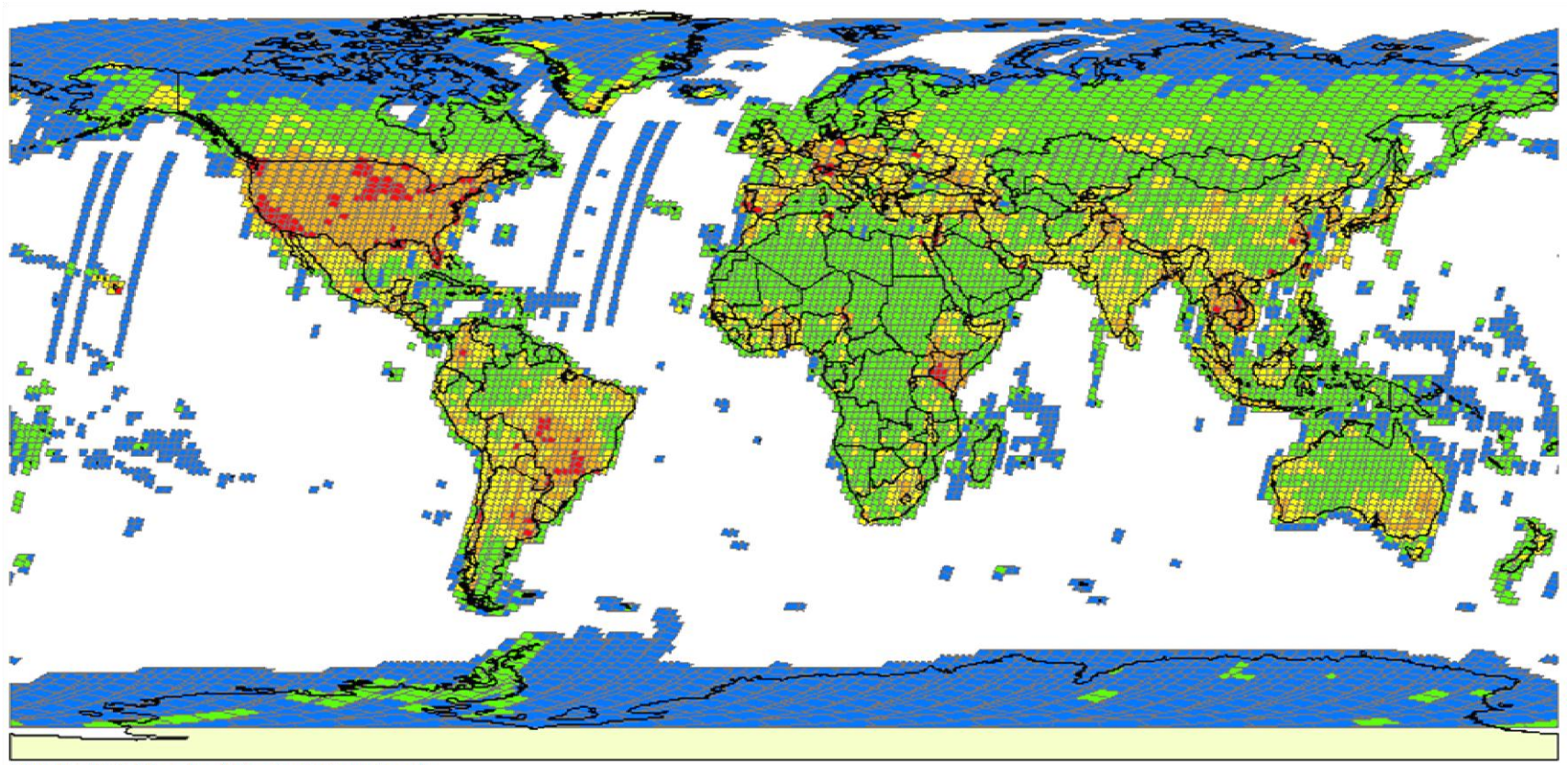


LGAC WRS1 Scenes
Status as of February 28, 2015
Acquisition Date Range: July 26, 1972 through March 31, 1983
3,262,749 Cumulative Scenes Delivered
165,013 Total WRS1 Scenes Acquired
3,521 Unique WRS1 Path/Rows

1 - 20 | 21 - 44 | 45 - 67 | 68 - 94 | 95 - 135

USGS

OLI/TIRS Downloads

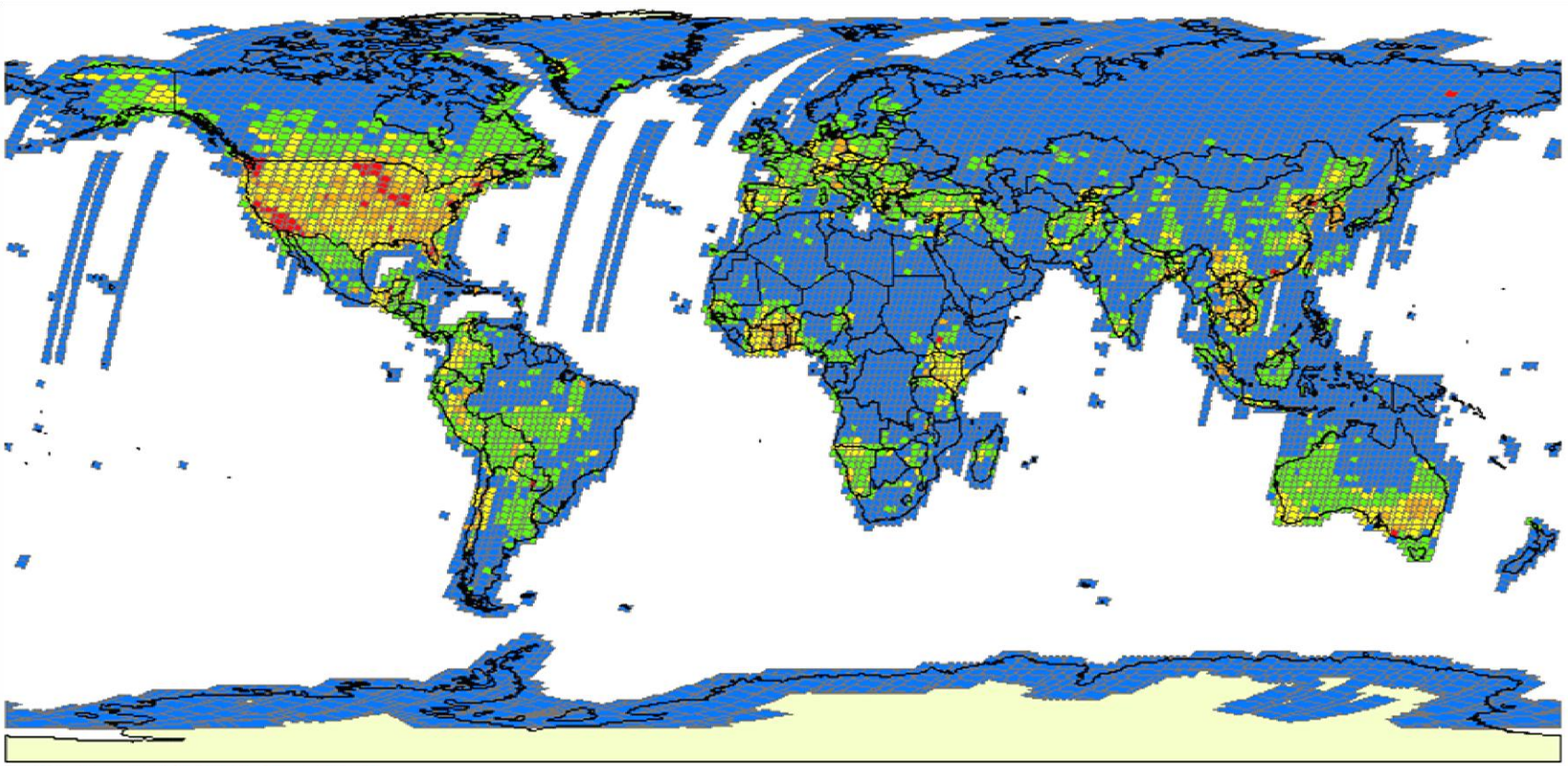


OLI & TIRS Standard Product Downloads
via User Interface and Bulk Users
October 01, 2014 through March 31, 2015
3,687,453 Total Cumulative Scenes Delivered
1,376,180 Total OLI & TIRS Scenes Delivered
14,483 Unique OLI & TIRS Locations

1 - 62 | 63 - 134 | 135 - 240 | 241 - 422 | 423 - 1014

USGS

ETM+ Downloads

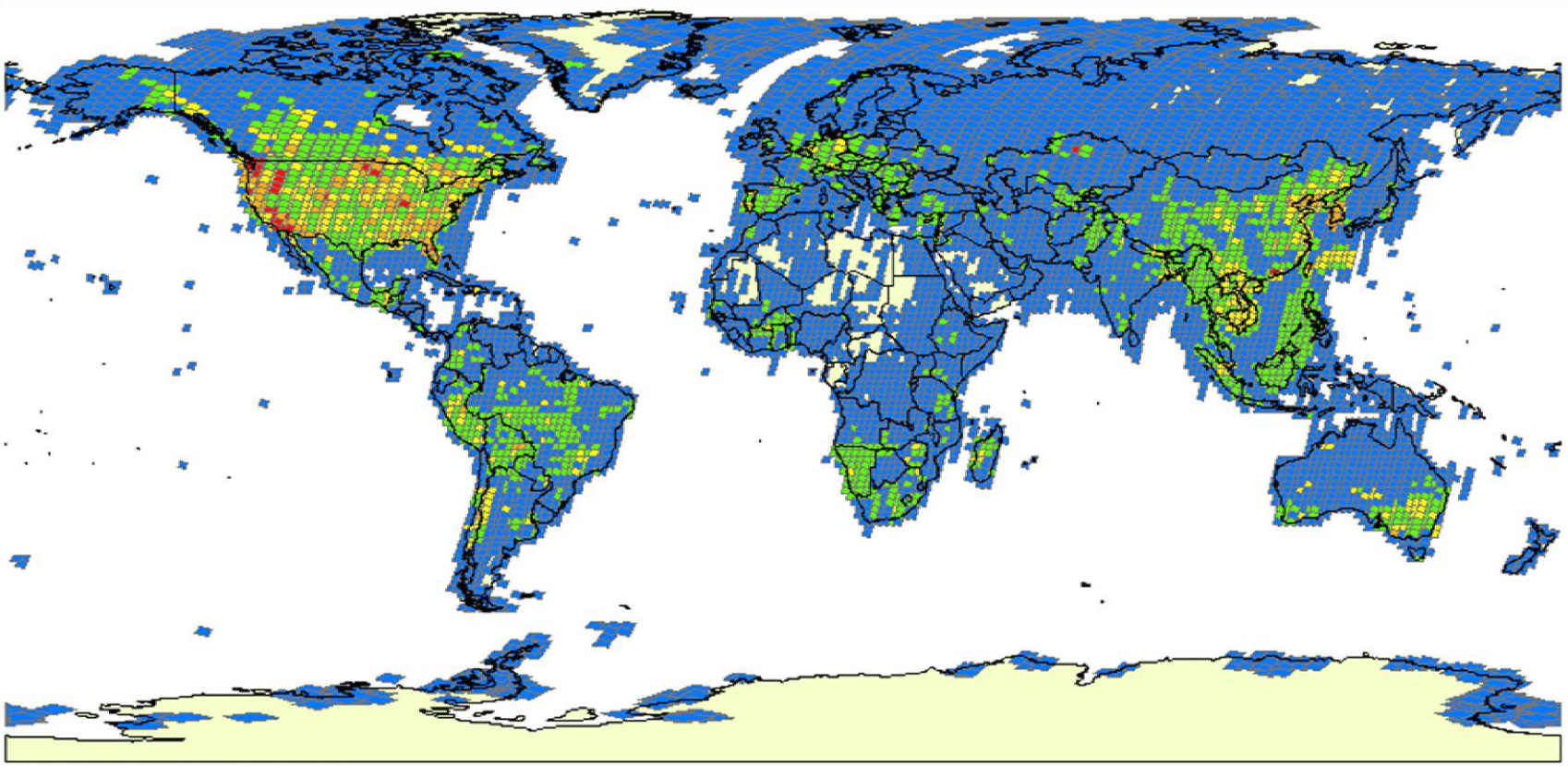


ETM+ Standard Product Downloads
via User Interface and Bulk Users
October 01, 2014 through March 31, 2015
3,687,453 Total Cumulative Scenes Delivered
958,955 Total ETM+ Scenes Delivered
11,419 Unique ETM+ Locations

1 - 85 | 86 - 240 | 241 - 485 | 486 - 973 | 974 - 3614

USGS

TM Downloads

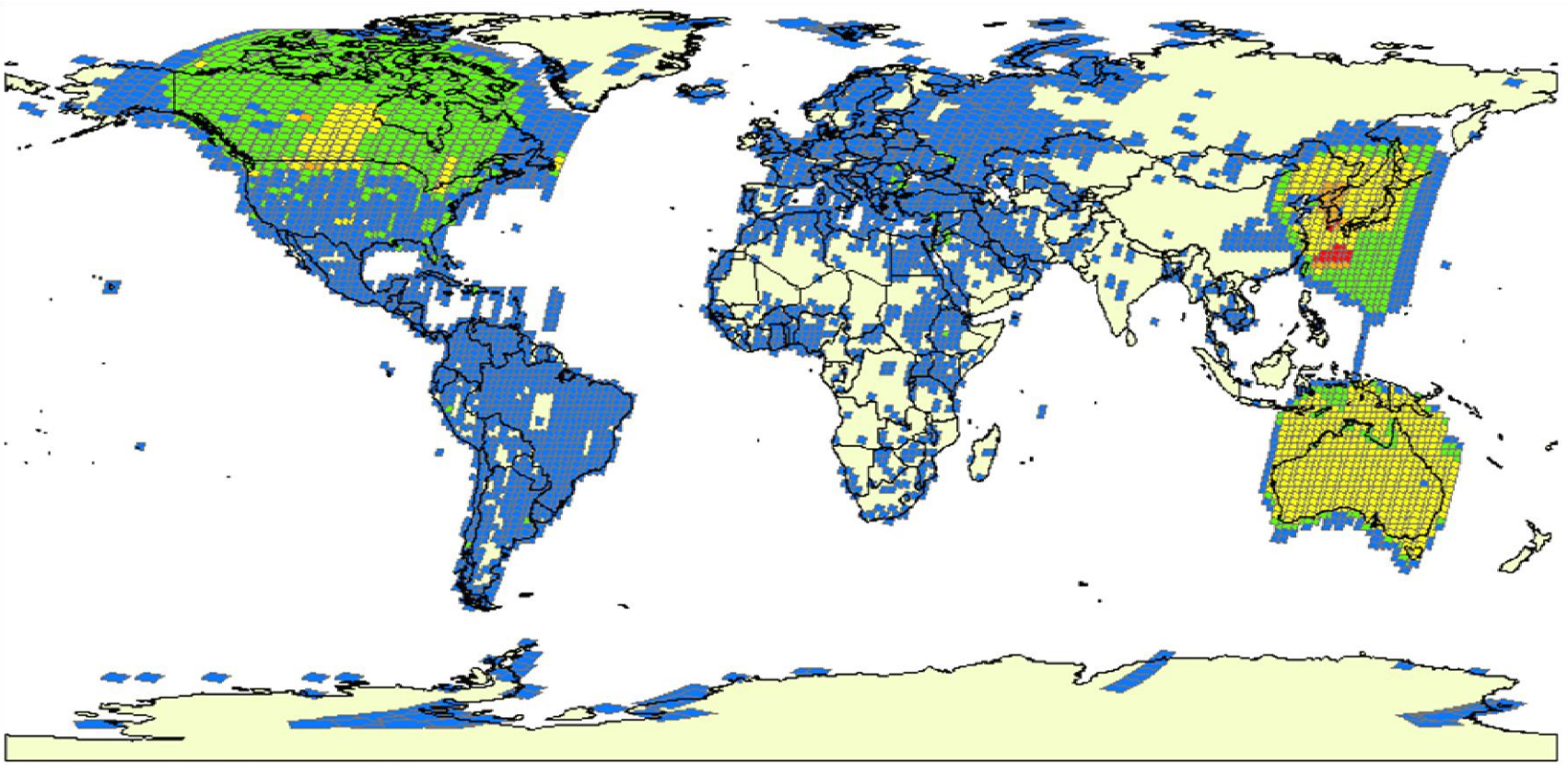


TM Standard Product Downloads
via User Interface and Bulk Users
October 01, 2014 through March 31, 2015
3,687,453 Total Cumulative Scenes Delivered
885,551 Total TM Scenes Delivered
9,230 Unique TM Locations

1 - 104 | 105 - 326 | 327 - 757 | 758 - 1666 | 1667 - 7665

USGS

Landsat 4-5 MSS Downloads



L4-5 MSS Standard Product Downloads
via User Interface and Bulk Users
October 01, 2014 through March 31, 2015
3,687,453 Total Cumulative Scenes Delivered
255,032 Total L4-5 MSS Scenes Delivered
5,468 Unique L4-5 MSS Locations

1 - 40 | 41 - 102 | 103 - 226 | 227 - 489 | 490 - 1226

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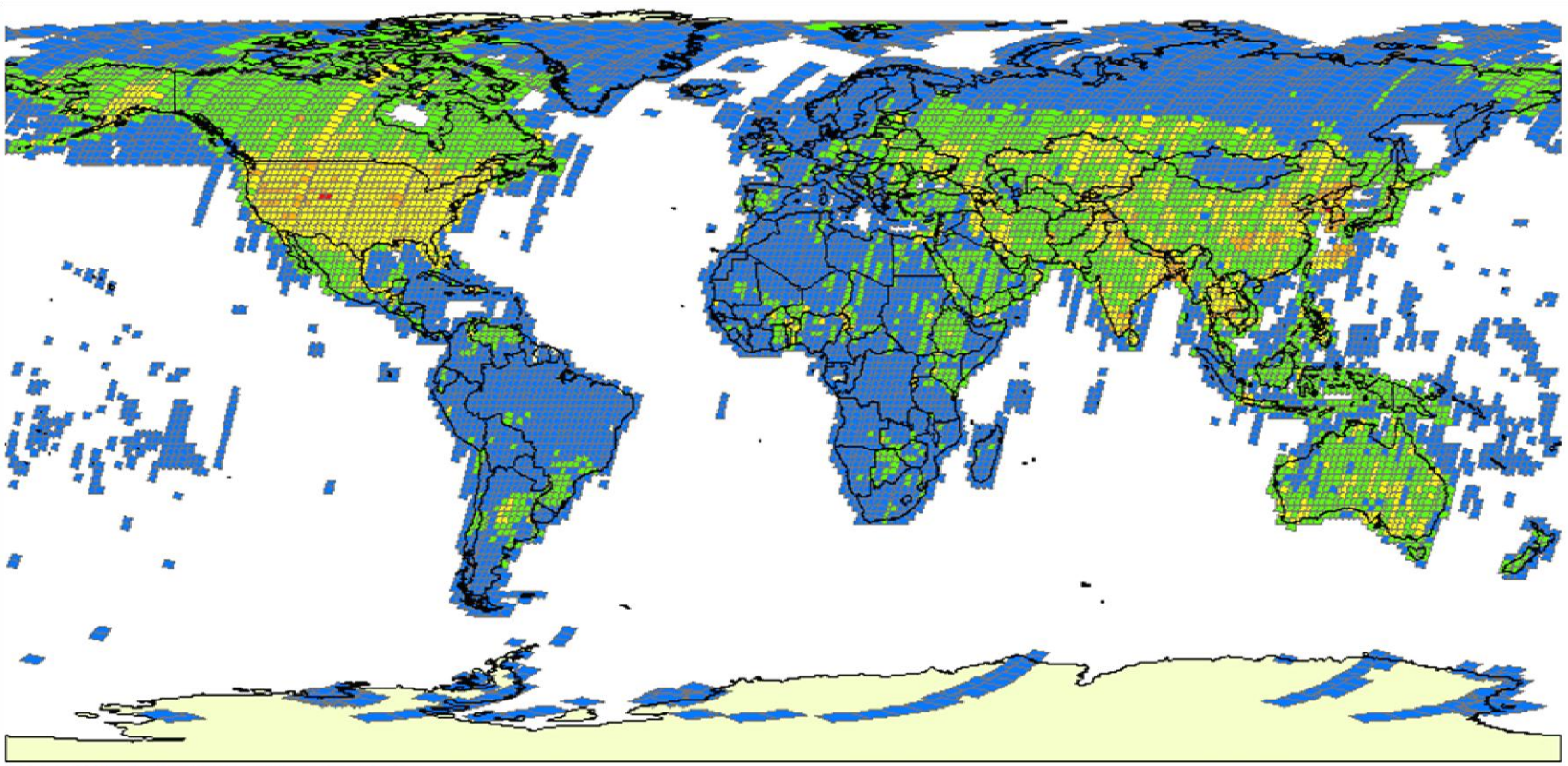
Landsat 1-3 MSS Downloads



L1-3 MSS Standard Product Downloads
via User Interface and Bulk Users
October 01, 2014 through March 31, 2015
3,687,453 Total Cumulative Scenes Delivered
211,735 Total L1-3 MSS Scenes Delivered
11,236 Unique L1-3 MSS Locations

1 - 15 | 16 - 35 | 36 - 80 | 81 - 294 | 295 - 613

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Long-Term Acquisition Plan Controls

- Cloud predictions better than cloud climatology increases probability of acquisition
- Sun elevation constraints
  - Landsat 7 (15° N & 5° S)
  - Landsat 8 (5° N & 5° S)
- Automatic cloud cover assessments of acquired images identify successful acquisitions
- Missed opportunity boost
- Reduced need
  - Vegetation phenology quantified by discrete seasonality records or continuous NDVI probabilities
  - Thematic Campaigns – requirements not well represented by seasonality (reefs, agriculture, volcanoes, glaciers, night, ocean, emergency)

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